Fisheries and Oceans Canada

Five-Year Research Agenda (2007-2012)

Canada

Fisheries and Oceans Canada

Five-Year Research Agenda (2007-2012)

Table of Contents

1. Preamble **3**

2. Context **3**

2.1 Fisheries and Oceans Science Program 3

2.2 Science Renewal's Framework for the Future 4

2.3 A Balanced Science Program 4

3. Drivers and Priorities for Aquatic Research **5**

3.1 Strategic Directions - Science Management Board 5

3.2 Ecosystem Science Framework 6

4. Five-Year Research Agenda **6**

4.1 Objectives and Goals 6

4.2 Research Priority Areas 7

I Fish Population and Community Productivity 7

II Habitat and Population Linkages 8

III Climate Change / Variability 8

IV Ecosystem Assessment and Management Strategies 9

V Aquatic Invasive Species 10

VI Aquatic Animal Health 10

VII Sustainability of Aquaculture 11

VIII Ecosystem Effects of Energy Production 11

IX Operational Oceanography 12

X Emerging and Enabling Technologies for Regulatory and Policy Responsibilities 12

5. Multidisciplinary and Collaborative Research **13**

6. Research Plan **14**

1. Preamble

The focus of this document is **research**, one of the five key functions of the Science program. The other Science functions are: **monitoring; data management; scientific advice**; and **products and services**. All these functions, or components, are critical in their own right but they are all inter-connected. This document is not a "DFO Science Plan" as it does not try to capture all DFO scientific activities and programs and how they relate to each other.
The purpose of this **living** document is to outline an agenda to guide DFO's **research** program through the next five years. It details the background and drivers that led to the development of the agenda and highlights the need for a multidisciplinary and collaborative approach.
This agenda is comprehensive, but it should be noted that DFO and Government priorities evolve over time. DFO Science does not have the capacity and the expertise to address all components of each priority area within a five year period. **Choices will have to be made with a view of maximizing flexibility, integrating our work and developing collaborations with research partners**. With this in mind, this research agenda, the first of its kind for DFO, provides strategic direction on how effort and resources will be focused to ensure their alignment with federal and departmental priorities. Furthermore, **it will be the basis for the development of a detailed research plan.**

One might question where stock assessment fits in the research agenda. DFO Science is committed to maintaining a comprehensive stock assessment program and seizing all opportunities to support its continuing evolution within an ecosystem approach. Stock assessment requires a comprehensive set of activities such as long-term monitoring of species and their environment, analysis of commercial and research data, and the provision of scientific advice. Stock assessment also requires research to better support the management of the fisheries resources and this research plan will strongly contribute to the development of new knowledge that will be incorporated into future assessments.

A working group of DFO scientists from coast-to-coast-to-coast contributed to the development of the research priorities included in this research agenda.

2. Context

2.1 Fisheries and Oceans Science Program

Fisheries and Oceans Canada (DFO) has one of the most complex and comprehensive Science programs in the federal government, both in terms of function and geography. **It supports fisheries, aquaculture, oceans, and habitat management and maritime safety (client sectors) objectives and includes marine and freshwater environments and species.**
In spite of the increasingly integrated nature of departmental knowledge needs, client sectors require science advice and support that reflects their specific needs. They have come to rely on the traditional single-activity approach and are demanding increasingly specialised products and services. This need for integration, combined with increased demands for new types of knowledge and limited resources, is challenging the Science program's capacity to effectively support departmental and federal priorities.

In 2004, DFO began a comprehensive review of its Science Program to assess how it fit with new departmental strategic objectives and priorities and to identify specific changes required to better support DFO policy and decision-making. The Review recommended that the DFO Science Program realign its activities to:

- meet the needs of the Department, the federal government, and Canadians;
- reflect modern delivery mechanisms; and
- be effective, affordable, and sustainable for the long-term.

2.2 Science Renewal's Framework for the Future

In 2005, Science Renewal was launched to implement the recommendations of Science Review. Science Renewal identified the key changes necessary for achieving a more transparent, integrated, and effective Science Program including: ensuring Science activities are aligned with federal and departmental priorities; employing modern governance and accountability practices; implementing national funding decisions; and formalising Strategic and Business Planning practices.

Science Renewal's Framework for the Future aims at creating a vibrant aquatic science program based on excellence that supports and informs DFO and Government needs and best serves Canadians. The Framework outlines a renewed and realigned DFO Science Program that is **relevant**, **effective**, **affordable**, and **valued**. It also incorporates the three national science themes that support DFO's strategic outcomes:

1. understanding and describing the state of aquatic ecosystems
2. assessing and mitigating the impacts of human activities
3. supporting maritime safety, security, and sovereignty

2.3 A Balanced Science Program

Modern and effective delivery of science activities is achieved through a balanced Science program that is characterised by:

- Building long-term stability required to support decision and policy making by maintaining:
  1. An integrated **monitoring** program focusing on aquatic ecosystems; and
  2. A comprehensive scientific **data management** program.
- Maximising flexibility to respond to the evolving departmental and government-wide priorities by:
  1. Carrying out an integrated **research** program aligned with priorities;
  2. Providing timely and sound **scientific advice** supporting decision and policy making; and
  3. Developing **products and services** for the Public Good.

These five science functions, or components, are critical in their own right but they are all inter-connected. For instance, progress in research supports advances in science advice; new knowledge brings refinements to the monitoring program; high quality databases support the development of advice and services needed for decision and policy making.
Each science function is the subject of a planning process designed to capture the issues and challenges. It is in this context that:

- operational plans for monitoring are being developed for the Atlantic, the Pacific, the Arctic, Freshwater and Pacific salmon;
- a data & information management plan was recently completed and its recommendations are being implemented;

- a new science advice process has been implemented;
- a products & services operational plan is being developed; and
- a Five-Year Research Agenda (the subject of this document) has been developed.

These provide the foundation for generating and developing new knowledge bases or improving the applications of existing information.

3. Drivers and Priorities for Aquatic Research

Research is one of the essential components of a modern and cost-effective science program. As such, it is critical to develop a plan that focuses the **research** needed to ensure DFO Science has the necessary knowledge to support the Department's strategic objectives and priorities.

Aligning DFO's research agenda with established and forward-looking Departmental and government-wide priorities and issues of importance to Canadians is essential if our research and knowledge is to be both relevant and timely. In setting DFO's research priorities, a wide variety of documents was considered, including:

- DFO "2005-2010 Strategic Plan: Ours Waters, Our Future"
- DFO Transformational Plan (2005)
- Major Government priorities such as Climate Change, the North and Biodiversity
- DFO Ecosystem Science Framework in support of Integrated Management (2006)
- Report of the DFO "Aquatic Science 2020" workshop (2003)
- Report of the Science-Based Departments and Agencies "Beyond the Horizon; Identifying Emerging Priorities for S&T Integration" workshop (2005)

These documents clarify the priority issues, drivers, and challenges that may affect our research agenda and help identify the significant new knowledge required to inform policies, regulations, standards, and decisions.

3.1 Strategic Directions - Science Management Board

Obtaining clear strategic direction is essential to fine-tuning the alignment of a research agenda. By establishing its Science Management Board (SMB) in 2005, DFO took a major step toward this objective. **The SMB identifies science-related issues of importance to achieving DFO mandated objectives; establishes priorities in need of science support; and provides strategic direction on work planning for DFO Science.**

In October 2005, the SMB indicated that its two highest priorities for DFO Science were:

- A Science program that supports ecosystem-based management.
- A renewed Science workforce in light of changing demands and attrition.

The SMB also directed Science to develop a five-year research plan that supports the strategic agenda of the department and the government of Canada.
This led to the development of the **Ecosystem Science Framework** (completed), a **Science Human Resource Strategy** (in progress) and this **Five-Year Research Agenda**.

3.2 Ecosystem Science Framework

Aquatic ecosystems are increasingly affected by human activities. Limiting possible impacts and making human activities more sustainable is the complex task of policy-makers and managers who, in turn, rely on scientists for advice on which to base their decisions.

Ecosystem science is the foundation for the science needed to support the integrated management of diverse human activities such as fishing, aquaculture, transportation, and oil & gas exploration that are regularly undertaken in the same area. Ecosystem science provides decision-makers managing fisheries, aquaculture, habitat, and oceans resources and the recovery of species-at-risk essential advice on how these activities interact with each other and affect aquatic ecosystems. Ecosystem science is needed to inform the Department's policies and management practices and determine the necessary features of our Science activities.

An ecosystem science approach also means changing the way DFO provides science support. Scientists have to provide decision-makers with comprehensive ecosystem advice about how human activities may interact with other activities being undertaken in the same aquatic ecosystem or take adequate account of major environmental drivers in the ecosystem. **Implementing this new approach is far more than redistributing limited resources, it requires a philosophical and cultural shift and a change in the make up of the Science Program workforce**. These important issues are being addressed in the Science Human Resources strategy currently under development.

In response to the SMB, DFO Science developed the "New Ecosystem Science Framework in Support of Integrated Management". It provides a cost-effective and comprehensive approach for identifying, monitoring, and interpreting trends important to an ecosystem's sustainability and integrating existing knowledge about the effects of human activities on important ecosystem features.

As such, the Ecosystem Science Framework provides direction for moving the DFO research agenda to support integrated management of human activities.

4. Five-Year Research Agenda

4.1 Objectives and Goals

Excellent research is a vital component of the Science program. The Five-Year Research Agenda is designed to support current and emerging priorities and identify those areas that require new scientific knowledge in the medium and longer term. One of the key objectives of the research program is to create new knowledge and methods that will support the development of better advice required for policy and decision making and in particular, ecosystem-based management.

DFO's research program is multi-faceted and reflects the diverse demands for knowledge associated with existing, emerging, and increasingly complex science-based issues involving a variety of ocean industries, technologies, and a multitude of aquatic uses. In recent years, this demand for new types of knowledge has challenged the research program's capacity to deliver effective advice, products, and services. It has also served as a catalyst for reassessing and prioritising existing and future demands for scientific knowledge based on established and emerging priorities.

Identifying emerging research priorities and maintaining the flexibility to address a wide range of issues will continue to be a key role of DFO scientists. As such, DFO Science

must ensure it hires and retains balanced expertise that can respond to issues in an integrated ecosystem approach.

While the majority of DFO Science effort will be directed at making progress in particular priority areas, **a balance of critical skills will be maintained to ensure we have the necessary capacity to meet the ongoing research needs of the Department**. These skills are foundational; they support a wide variety of program areas and they are essential to the continuing viability of the DFO Science Program. Requirements to support regulatory responsibilities and advice include a wide-range of activities that also support fish, marine mammal, and habitat research.

4.2 Research Priority Areas

The following **research priority areas** reflect the research that is considered essential to address federal and Departmental priorities and public good needs for the next five years. They are strongly influenced by the Ecosystem Science Framework and include basic and applied research needed for developing **new** knowledge and improving the use of **existing knowledge**. Research priorities areas are interconnected and, to a large extent, integrated. Research undertaken in one area is expected to contribute to DFO's knowledge base in other areas. This is a key characteristic of the research agenda as it ensures research activities support an integrated management approach. The rationale for each of these priority areas is also important as it provides the raison d'être (e.g. describing the issues or problems) to carry out research.

The following priority areas of research are not ranked. It has been proposed that they be grouped under a limited number of themes, but no consensus has been reached at this point.

I Fish Population and Community Productivity

Rationale

Effective management of fisheries requires an in-depth understanding of fish population and community productivities. Changes in the productivity and resiliency of key species may have serious consequences for the dynamics of entire ecosystems and the sustainability of fisheries. These changes might be triggered by several biological, physical and environmental factors as well as by human activities. With ecosystems changing and some species becoming at risk, research is needed to better understand factors and processes controlling population and community productivity.

Priority Areas for Research

- spatial patterns of spawning components, migration and movement at different life stages and age / growth studies of commercially important species
- impact of fishing on the benthos, species at risk and loss of genetic diversity
- bottom-up (primary and secondary production; food limitation; sinking of biological material to the sea floor) versus top-down (mortality by predation) ecosystem processes and the role of biodiversity in the control of productivity in benthic and pelagic populations
- food habits of important apex predators (e.g. marine mammals) and their impacts on commercially important species
- long term changes in carrying capacity of populations and ecosystems due to climate variability

- management strategies for species with limited knowledge and understanding of population dynamics

II Habitat and Population Linkages

Rationale

The alteration or destruction of fish habitat, either by human or natural means, may have lasting effects on fish populations, ecosystem resilience, and the sustainability of resource uses. Knowledge of the linkages between habitat productive capacity and population productivity (fish, plankton, marine mammal) is essential to understand the effects of anthropogenic and natural changes to habitat quantity and quality. Research is needed to better understand linkages between habitat productive capacity, population productivity, and biodiversity to be able to assess the effectiveness of mitigation and compensation measures for human activities.

Priority Areas for Research

- developing and testing methodologies that link population and community productivity to habitats and include concepts such as critical habitat and habitat-related thresholds (bottlenecks);
- quantifying and calibrating effects of human-induced and natural changes to habitats and the aquatic resources they support, including considerations such as sensitivity, resilience, intensity, duration, and reversibility of effects (spatial and temporal);
- developing best practices for measuring habitat impacts including:
    - methods for classifying and quantifying habitat attributes,
    - the identification of surrogates of productive capacity for major habitat types,
    - the validation of "pathways of effect" (relationships between harmful actions on habitat and populations),
    - the development of indices, models, and tools to support decision-making;
- assessing the effectiveness of mitigation and compensation policies for human activities negatively affecting habitats;
- integrating surveying and sampling methodologies (high-resolution bathymetry and seabed mapping, acoustic determination of substratum, remote sensing distribution, and conventional biota sampling) with habitat attributes and link them to population productivity and biodiversity.

III Climate Change / Variability

Rationale

Climate change means ocean change given the numerous physical and biochemical interactions with the atmosphere. **As climate changes, biological and physical conditions in the oceans are modified, which affect the sustainability of human uses of aquatic resources, as well as the safety of coastal areas**. Research is needed to better understand, detect, and forecast changes and provide scientific information for developing adaptation strategies.

Priority Areas for Research

- analysing climate change projections from the Canadian Centre for Climate Modelling and Analysis (CCCMA) coupled carbon-climate model and other international models and developing the next generation models at CCCMA
- downscaling global climate model projections and interpreting their impact on Canadian waters, including freshwater systems
- assessing flood risks and develop possible mitigation strategies
- analysing climate change impacts on contaminant pathways
- assessing the resilience of aquatic populations, from algae to marine mammals through:
    - study of spatial and temporal variations in life history characteristics of wild populations of key species in different physical and biological environments ,
    - study of key species' life history characteristic variations and ontogenetic changes in metabolism and potential biological-chemical-physical links related to, growth, maturation and behaviour through experimental work that simulates a variety of environmental conditions,
    - integration of field and lab information into simulations
    - inclusion of impacts of climate change on populations in fishing plans

IV Ecosystem Assessment and Management Strategies

Rationale

Integrated management of individual and multiple human activities requires management strategies that are risk-based and integrate information on the status of ecosystems and how human activities may affect ecosystem components and structure.

Priority Areas for Research

- developing different approaches (e.g. qualitative or quantitative) to evaluating the performance of management strategies for the ecosystem approach
- evaluating the performance of alternative management tools, including spatial management measures such as Marine Protected Areas and catch and effort limitations in harvest management, in protecting and ensuring sustainable use of both the targeted resources and other parts of ecosystems
- undertaking ecosystem modelling to consolidate knowledge of the ecosystem to support evaluation of management strategies
- developing and evaluating risk assessment methodologies to allow prioritization of human impacts on ecosystem components
- evaluating the performance of indicators in relation to conservation objectives of integrated management, including cumulative impacts
- developing ecosystem status reports to meet the needs of diverse clients of integrated management as well as the general public
- working with academia to develop research approaches that ensure consideration of the ecological, social, and economic dimensions of management are fully integrated in the evaluation of management strategies

V Aquatic Invasive Species

Rationale

Aquatic invasive species (AIS) are one of the leading threats to aquatic biodiversity and ecosystem health. They have the potential to displace domestic species that support traditional fisheries and have significant negative impact on aquaculture. Research is required to support the development of a regulatory framework and guide the development and implementation of management measures, including prevention, rapid response, mitigation, and control activities.

Priority Areas for Research

- developing ballast water treatment technologies
- refining predictive modelling of future invaders
- determining the best methods for early detection of new invaders and monitoring the spread existing ones
- developing rapid response and ongoing mitigation and control methods
- refining risk assessment methods to determine the risk of AIS to Canada's aquatic ecosystems
- understanding aquaculture interactions with invasive species such as tunicates

VI Aquatic Animal Health

Rationale

Diseases play a central role in influencing the viability of both cultured and wild populations of aquatic organisms. Disease outbreaks can have major ecological effects on aquatic resources and severe economic impacts for the sustainability of aquaculture species. To improve management of wild and cultured resources, research is needed on disease agents in nature and the potential risks and effects of disease transfer between fish.

Priority Areas for Research

- identifying the causal agents of emerging diseases that may compromise the health of ecologically and commercially significant wild and cultured aquatic organisms
- assessing the viability and movement of natural pathogens between cultured and wild aquatic animals (bi-directional)
- identifying major environmental physical and chemical (i.e., contaminants) factors and host physiology and genetic variables influencing aquatic animal health in nature

VII Sustainability of Aquaculture

Rationale

Long-term sustainability of aquaculture requires the development of ecologically appropriate production technology and environmentally sustainable practices. The successful implementation of DFO's Aquaculture Policy Framework requires scientific advice that better supports policy and decision-making. There is a need to carry out research on the development of high efficiency and environmentally friendly culture technology and environmental interactions.

Priority Areas for Research

- investigating disease transmission (bi-directional) between wild and cultured stocks and developing aquaculture vaccines
- developing biological and oceanographic models, collecting lab and field data to allow prediction of ecological effects (near and far-field) of aquaculture, and determining carrying capacity of aquaculture areas
- assessing the risk of genetic and ecological interaction between cultured, enhanced (e.g., hatchery) and wild fish, developing technology to minimise wild/cultured fish interactions, and assessing efficacy of captive breeding programs for endangered stock rebuilding
- assessing the impact of aquaculture on species at risk
- developing high-efficiency, environmentally-friendly, and industry-diversifying culture technologies for salmon, alternate fish, shellfish, and algal species
- using biotechnology, genomics, and genetics to improve commercially important traits (e.g., growth and reproduction) and assess changes from wild type for use in risk assessments

VIII Ecosystem Effects of Energy Production

Rationale

Energy development in Canada (mainly offshore oil and gas, hydroelectricity, and oil sands) is rapidly accelerating and is expected to be substantial in the near future. DFO Science is called on to evaluate risks, potential impacts, and mitigation options in these energy-related undertakings. Significant advances in research are needed to augment the existing knowledge base so DFO can participate effectively in the planning, evaluation, and implementation stages of these projects.

Priority Areas for Research

- Investigating the impacts of flow management and water level regulation on habitat and productivity in freshwater, estuarine, and marine environments and developing ecosystem-based limits for river water withdrawals
- assessing the effectiveness of fish passage criteria and systems
- assessing the impact of energy development on species at risk
- evaluating impacts of creating and operating large reservoirs and resulting large scale ecosystem changes

- assessing the impacts of activities related to hydrocarbon exploration, production, and transportation on marine and freshwater ecosystems with a focus on seismic noise, produced water, oil spills, and pipeline construction
- evaluating the effectiveness of mitigation and compensation measures designed to offset development impacts
- evaluating the impacts of tidal energy initiatives on oceanographic and ecosystem properties

IX Operational Oceanography

Rationale

Search and rescue operations, safe navigation, and the dispersion of pollutants and ballast water organisms all require now-casts and forecasts of the state of the ocean. To predict the ocean's present and future state (this is Operational Oceanography) research is needed to better understand oceanic processes and the ocean's circulation.

Priority Areas for Research

- modifying, applying and using oceanographic models
- developing flexible modelling systems that allow nesting of high resolution sub-domains in regions of specific interest
- developing data assimilation capabilities for physical and biological variables
- developing fisheries and ecosystem models, which link the state-of-the-ocean to population and ecosystem processes
- developing and applying models for high risk events like tsunamis and storm surges
- researching and developing very high-resolution models of near-shore zones

X Emerging and Enabling Technologies for Regulatory and Policy Responsibilities

Rationale

Science support for DFO's regulatory and policy responsibilities often depends on advanced technologies. On the other hand, **industry's use of new technologies may pose new challenges to DFO regulatory responsibilities**. As such, DFO Science must keep abreast of emerging technologies such as informatics, genetics, genomics, biotechnology, bio-remediation, geomatics, and remote sensing. Research on new technologies is needed to:

- Enhance the ability of Science of performing research to gain new knowledge.
- Understand the potential effects of some technologies, such as modified organisms.

Priority Areas for Research

- identifying genetic markers for: rapid or remote species identification; strain and stock identification for species at risk; quantifying migration and behaviour of fishery species; and documenting responses to climate change and point source pollution
- developing techniques for analysing and interpreting data collected during multibeam surveys
- identifying and monitoring responses of aquatic organisms to environmental and anthropogenic stresses through population genetics and genomics

- developing technologies for mediating natural recovery in contaminated sites and for bio-remediation strategies for mitigation
- developing techniques to conduct bathymetric surveys of near-shore areas
- developing and applying bathymetric mapping and geomatics technologies to quantify seafloor properties, particularly in the nearshore zone, and of the effects of human activities on those properties
- identifying and evaluating aquatic animal models for enabling risk assessment science
- evaluating the efficacy of preventative and mitigative measures to prevent interaction between wild and novel aquatic animal strains
- developing technologies for remote sensing to detect, quantify and track the presence and abundance of particular individuals, species, species groups, or other ecosystem components, where that information is used directly in DFO's regulatory functions
- improving the effectiveness of accessing and using information required for DFO's regulatory responsibilities

5. Multidisciplinary and Collaborative Research

DFO Science recognises that it cannot support a shift to an ecosystem-based management approach by itself. Research to support ecosystem-based management will have to address increasingly complex questions and engage a broad range of research capacities. DFO Science does not have the capacity to develop and retain the necessary expertise, experience, and resources to support integrated management alone. As such, the purpose of the research agenda is to define DFO's research priorities and knowledge gaps to ensure the necessary expertise is identified.

The realigned DFO Science Program must effectively draw on the necessary expertise, wherever it resides. It is well recognised that, to be affordable and effective, DFO's aquatic research must be aligned with Canada's collective research effort and reflect the contributions of its partners in knowledge generation. DFO Science will partner with other experts and collaborate with other agencies wherever possible – both nationally and internationally – including other DFO sectors, academia, universities, Aboriginal groups, industry, non-governmental organisations, and other government agencies. Collaborative approaches and partners will be critical in the delivery of the DFO research plan.

Centres of Expertise (COEs) are an example of this collaborative approach. DFO Science is setting up COEs to maximise research in support of federal and departmental priorities and optimise the delivery of high priority research in partnership with industry, other federal departments, provincial and territorial governments, and academia. COEs enable DFO to support unique research requirements in areas of the Science program where national delivery and co-ordination is difficult due to the scope of the research requirements or specific, essential research outputs.

COEs are designed to enable DFO to address long-term research issues that cannot be addressed by a single region or institute by bringing together diverse scientific expertise, either in a geographic location or through a virtual network. COEs provide essential collaborative research that develops the necessary knowledge to support decision-making and policy development.

6. Research Plan

The research agenda provides strategic direction on how effort and resources will be focused to ensure their alignment with federal and departmental priorities. It also provides the basis for the development of a detailed research plan.

While developing the research plan, the focus will be on ensuring a balanced research program that is integrated, flexible and able to respond to new priorities, and built around long-term collaborations with our partners.

Following the discussions at the Science Renewal workshop that will be held in Montebello on February 6-8, 2007, a detailed research plan will be finalized and submitted to the DFO Science Management Board for consideration in the fall of 2007.